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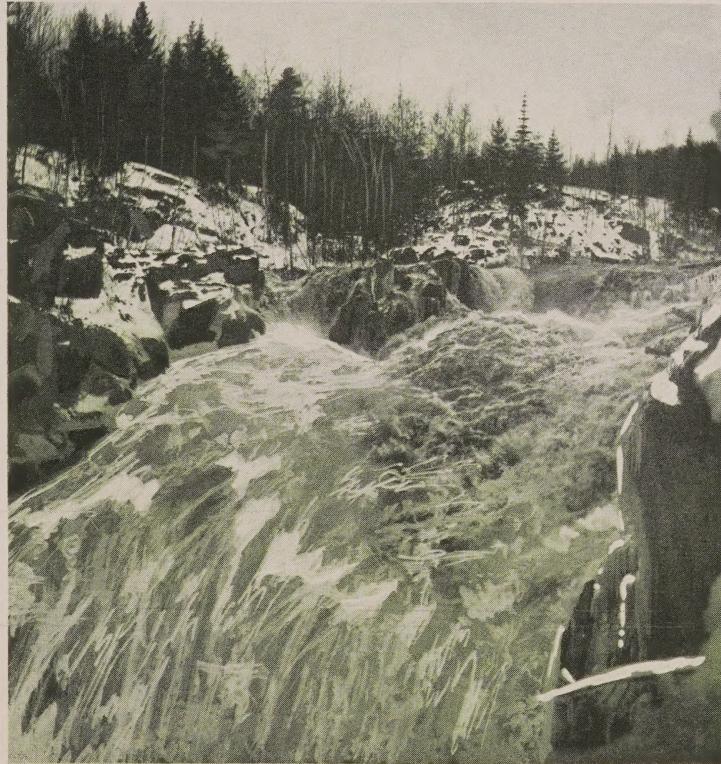
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CONTENTS

Vol. V. No. 1
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| | Page |
|-------------------------------|------|
| Editorial | 2 |
| Technical Section | 3 |
| Review of the Technical Press | 11 |
| Who's Who in Hydro? | 18 |
| Hydro News Items | 19 |
| Letters from Readers | 21 |



Editorial

Do You Keep Your Bulletins?

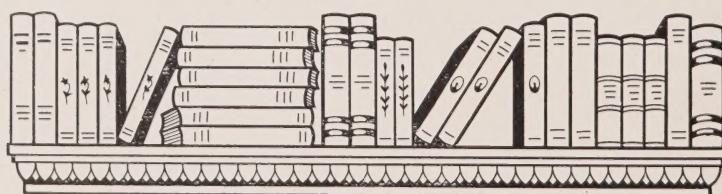
THE Editor has several times received enquiries regarding binding volumes of THE BULLETIN and supplying satisfactory covers and binders. It occurs to us that perhaps a number of our readers have the same thought in mind. If that is so, we can undoubtedly arrange to have separate volumes of THE BULLETIN bound at a minimum price, or if more satisfactory we can supply special cloth covered binders.

In order to gauge the probable requirements accurately we should like to have every reader of THE BULLETIN who wishes such covers or binding, write us and state his preference. We are of the opinion that a permanent book binding of flexible cloth, stamped in gold is the best method of permanently pre-

serving your file, but should like to positively ascertain if this view coincides with the wishes of our readers.

Upon receipt of your letters, we shall be in a position to quote prices on this work, which if it was individually attempted, would amount to quite a good price.

At the same time that you are writing us on this subject, look around and see if you can't also send us a good water power picture for use as a cover design. We have enough of this material to last for about three months, but we wish to keep our covers made up some time ahead, and it will assist us greatly if every reader keeps on the lookout for suitable illustrations for us. We hope that everybody will make it a point to keep this in mind.



Technical Section

The Tungar Rectifier

By F. K. D'ALTON

Assistant Laboratory Engineer

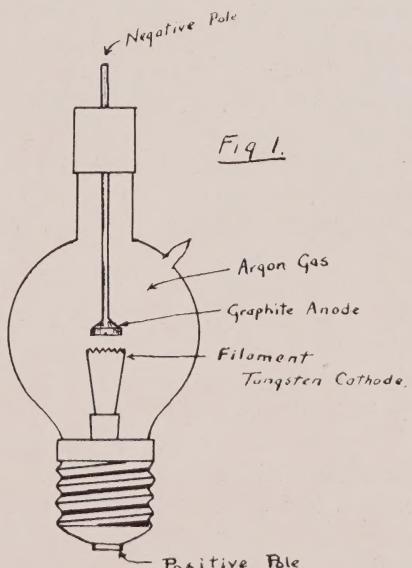


URING the past few weeks the Laboratory Engineers have been making a thorough investigation on the Tungar Rectifier, a small piece of apparatus for rectifying alternating currents at low voltages. This type of rectifier is designed primarily for the purpose of charging storage batteries but when arranged with different connections may be used in any case where a pulsating undirectional current is satisfactory in place of the steady direct current.

The Tungar Rectifier is a comparatively new article on the market having been produced recently by the General Electric Company as a result of experiments carried on in their Research Laboratory in Schenectady, New York.

For some time scientists have known that a vacuum tube, in which are contain-

ed a hot electrode and also a cold electrode, will permit current to flow between these in one direction only, namely from the cold electrode to the hot one. If used, then, in an alternating current circuit it will prevent the current from flowing in one direction but permit it to flow in the other, thus acting as a rectifier to give a pulsating current in one direction only. A device of this kind is termed a "One-half wave" rectifier on account of the fact that only one-half of the alternating current wave is available in the rectified current.



The rectifier as sold, consists essentially of a small single phase auto-transformer designed for the supply voltage at the desired frequency, and having two taps at about 3 volts apart, but both some distance from one end of the winding. On these two taps is carried, as load, the tungsten filament of the rectifying tube.

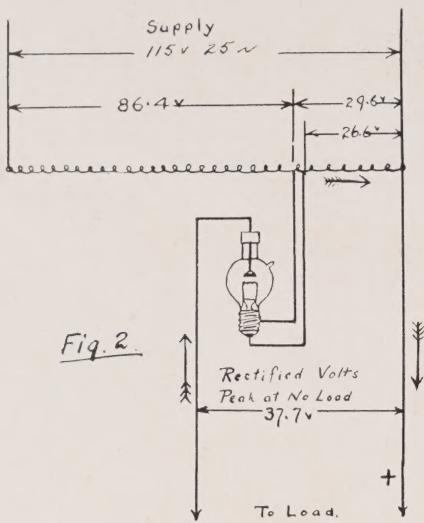


Figure 1 shows a cross section of the tube referred to in which may be seen the filament and the graphite block which acts as anode in the rectifying process. It will be noticed that the tube is designed to fit a mogul socket, in this way facilitating an interchange of tubes.

The bulb itself is made of glass about 3 inches in diameter and is filled with an inert gas. Argon, in a high state of purity and at comparatively low pressure. The graphite becomes the anode, that is, the terminal into which current flows from the outside circuit: the heated filament becomes the cathode, or the terminal from which current flows out to the outside circuit. Hence, inside the bulb the current flows from graphite to filament through about a half inch of argon gas.

Various metals have been used for the filament but tungsten has been found most satisfactory as it does not dissolve or contain any gases

and therefore permits of a better vacuum within the bulb.

All bulbs are carefully exhausted to the highest possible vacuum and then filled with the argon gas, but as certain impurities, even though present in very small quantities, will cause a more or less rapid disintegration of the filament and also very materially increase the resistance of the tube, it is necessary to employ some means of insuring absolute purity of the argon.

This is accomplished by the introduction of certain substances into the bulb before exhaustion, which chemically react with any such impurities as may be present. When the tube is started the purifier evaporates and deposits itself on the inner surface of the bulb causing a dark discoloration. The bulb when sold, therefore, has much the same appearance as a worn out tungsten or carbon lamp, but this discoloration does not in any way affect the operation of the tube, and it is only in the matter of appearance that it is objectionable.

When first placed in circuit and the current turned on the bulb is illuminated in much the same way

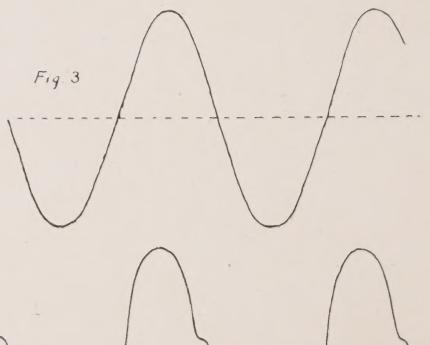
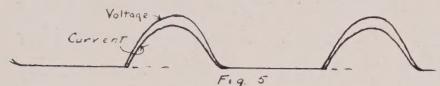


Fig. 4. Rectified Halfwave Voltage

and to about the same brilliancy as a low candle power tungsten lamp, but after carrying load for a few minutes the bulb emits a delicate light if the vacuum be not good. A new, correctly made bulb does not change color with increase in load, hence any such change may be considered as an indication that the bulb is wearing out.

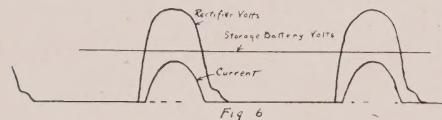
The life of a bulb varies from six hundred to three thousand hours. Some bulbs, however, have been



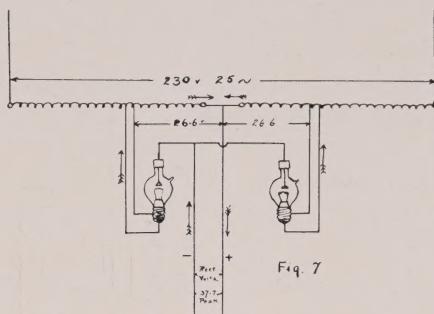
known to give over eighteen months of nearly continuous service. The failure always occurs in the filament since it is continually disintegrating while current is flowing through the tube from the anode to the cathode. The filament is made particularly rugged; and, operating on the low voltage of 2.5 to 3 volts, requires a current of 18 to 22 amperes.

One-Half Wave Rectification

The connections of a single rectifier for one-half wave rectification are shown in Figure 2. It will be



observed that the taps on the auto-transformer are at 26.6 and 29.6 volts respectively from one end, i.e., from the end which is carried through as the positive load wire, the negative load wire being connected to the anode (graphite block) of the tube. The rectified current,



though pulsating, will not change in direction and will flow as shown by the feathered arrows. The load is connected between the leads marked plus and minus in accordance with requirements as to polarity.

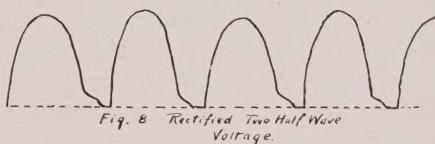


Fig. 8 Rectified Two Half Wave Voltage.

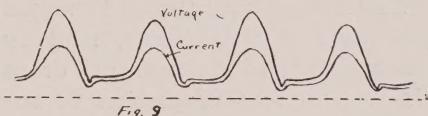
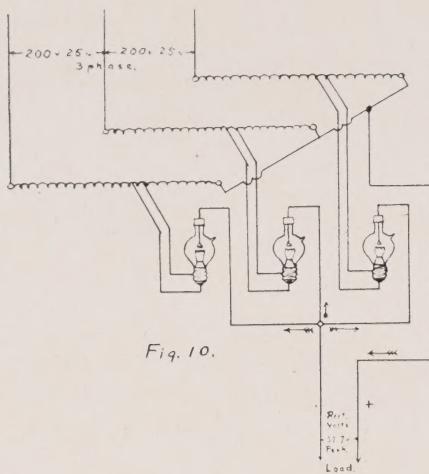


Fig. 9.

Figure 3 shows the pure sine wave of voltage just as recorded by the oscillograph from the 25 cycle lines of the Commission. The dotted line represents the zero value. The voltage between the positive lead (Figure 2) and the taps will be of the same shape and have a peak value of 38 volts, but as seen is alternating on both sides of the zero line.

The effect of the rectifier will be seen in comparing Figure 3 and Figure 4. It will be noted that in the latter, the voltage values are only in one direction, the lower



half of the wave is completely cut off. This wave is the rectified voltage at no load which has a peak value equal to 38 volts, but will indicate much less than this on a voltmeter. An A.C. voltmeter reads 16.8 volts whereas a D.C. voltmeter reads 10 volts.

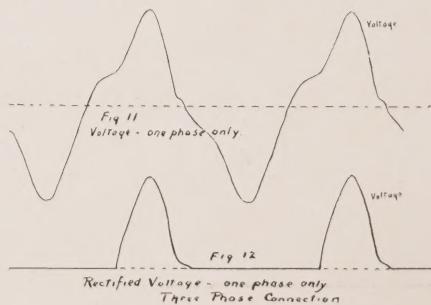
As load is applied and increased the value of the voltage, read by either type of instrument drops almost in exact proportion to the load current. Figure 5 shows the wave form of voltage and current with a load of 6 amperes with which the voltage is 7.5 volts (readings by direct current instruments only.)

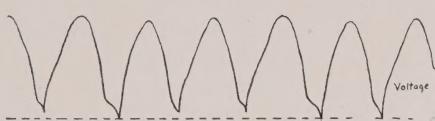
In the charging of storage batteries the rectifier finds its greatest use. It permits current to flow one way and will not allow any reversal even when the rectifier voltage is on the zero line, which it is for a large part of the time. Furthermore the rectifier is self-starting. The bulb starts and is ready to rectify as soon as the switch is thrown in on the supply circuit. If power goes off, the bulb will cool down, no current

can flow in either direction, and no harm can result. Upon power being re-established the bulb will automatically pick up its load and continue.

With a storage battery load the current only flows during the time that the rectifier voltage is higher than the storage battery volts, so that voltage and current waves will be as shown in Figure 6. It will be observed that the available voltage above battery volts will decrease very rapidly as the battery volts increase. Although a rectifier of this type may be successfully used to charge any battery having a voltage less than 38 volts, it becomes so slow that it is impractical if the battery voltage be above about 15 volts.

The power factor of the supply current is about 86% lagging with no load on the rectifier and gradually decreases as the load increases. The efficiency of the whole outfit at full load is 51.5% which is exceedingly low. These are not particularly advantageous features, but are not of so very great consequence if the convenience of using an automatic rectifier without moving parts, is taken into consideration.



Fig. 13. Rectified Voltage
Three phase connectionFig. 14. Full Resistance Load,
Three phase connection**Two-Half Wave Rectification**

Two single phase rectifiers may be connected according to Figure 7 on a single phase circuit with an impressed voltage of twice that used for one rectifier. Starting with the same voltage sine wave, Figure 3, we will find that the left hand rectifier will operate as the one in Figure 2, but the right hand rectifier will operate on the lower half of the wave not only rectifying, but reversing it so that we have a rectified voltage wave with twice the number of peaks obtainable by a single rectifier. Figure 8 shows this no-load voltage as obtained by two rectifiers. The zero line is dotted.

When load is applied by connecting resistances in circuit, the voltage wave is not only reduced in peak value but is seen to rise from the zero line (Fig. 9) indicating that at every instance the current has a positive value, varying, of course, but nevertheless

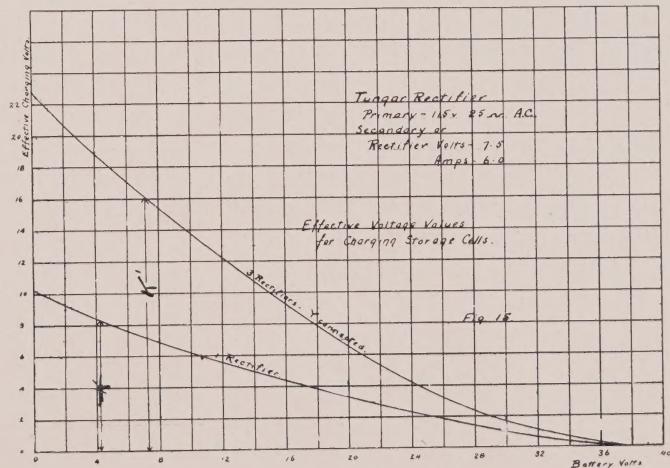
undirectional and at no time of zero value.

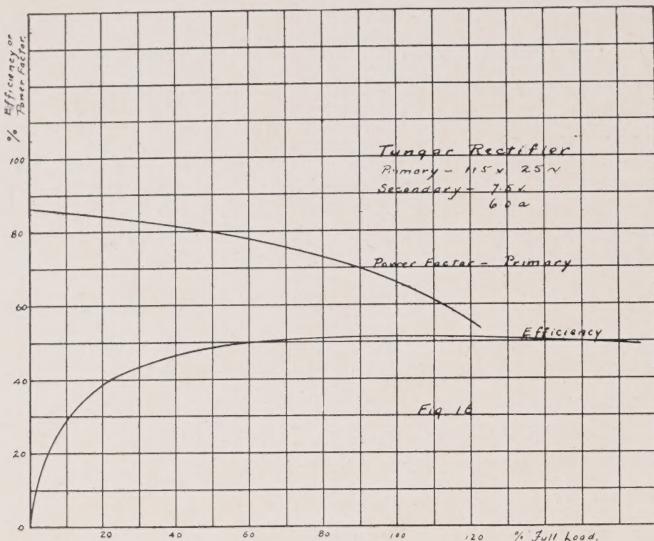
Two rectifiers with this connection (Figure 7) will charge a storage battery twice as quickly as one rectifier since we have two peaks of equal size per cycle instead of only one peak.

Three-Phase Rectification

On account of the fact that the Tungar tube is an absolute rectifier and positively prevents a reversal of current, it is possible to connect three single phase rectifiers in star on a balanced three phase circuit, as shown in Figure 10. The neutral of the star connection is brought out as the positive lead to the load. The three tubes are, of course, similar, and connections are the same—with regard to the different phases.

Figures 11 and 12, are, respectively, the unrectified and rectified voltages of one phase only. The three phases operating together give us a voltage at no load as illustrated in Figure 13. It will be





noted that the peaks shown in Figure 13 are more pointed than those shown in Figure 4; each one is therefore less effective than the single phase voltage wave and as a result the three rectifiers will not charge a storage battery quite three times as quickly as one will do. In the investigation we made we found that the three rectifiers on a three phase supply would act about 2.3 times as fast as a single rectifier. The effect, though, is balanced on the different phases.

When load is put on to the three phase equipment, the voltage leaves the zero line and also is reduced at the peak thereby reducing the amplitude of the ripples on the rectified voltage. This ripple has a frequency of 75 cycles on a 25 cycle circuit.

Protection

It will be seen that one of the primary leads forms a load lead when one rectifier is used, and that

in Figures 7 and 10, one load lead is connected to the primary side through the winding of the transformer. This makes it necessary to insulate our load for the full primary voltage. This feature must be considered in installing the rectifier for any service, but particularly so when for storage battery

work since the operator's hands are liable to be wet, and the danger in receiving a shock is thereby increased.

Time of Charging

It may be of interest to some readers to make a small calculation on the time required to charge a certain set of storage batteries. It is taken for granted that the reader realizes that the voltage of a battery rises while charging, and for simplicity in calculation we will let the average value of the battery voltage be represented by " V ".

Let the resistance—in ohms, of the battery as connected, be R , and let T be the time in hours.—The resistance of a rectifier is 0.7 ohms. It is obvious from a glance at Figure 4, or Figure 13, that the rate of charging is much slower for a battery of 20 volts than for one of 5 volts, not only because the resistance of the 20 volt battery is liable to be higher, but the value

of rectified volts in excess of battery volts will be less.

In Figure 15 are given two curves, one for the single phase rectifier and one for the three phase connection of three rectifiers. The values of K and K' , referring respectively to the one and three phase systems, are the effective values of the rectifier volts in excess of battery volts " V " for all values of battery voltage up to the peak of the rectified wave.

The charging current—one rectifier—will be equal to

$$\frac{K}{R+0.7}$$

The time necessary to charge equals

$$\frac{\text{Ampere hours required by one cell}}{\text{charging current}}$$

$$\text{or } \frac{R+0.7}{K} \times$$

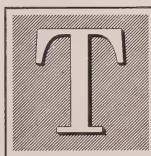
ampere hours required by one cell. The number of ampere hours necessary to charge a cell, or the ampere hours a cell is capable of delivering) is usually specified on the cell. It should be understood by the reader that " K " will be used as in Figure 7 connection, and replaced by $2K$ if two rectifiers are used or K' if three rectifiers be used in Figure 10 connection.

As before mentioned, the rectifier is automatic and the battery may be left to charge during the night, no harm resulting from one or several failures of the power supply.

The power factor and efficiency curves given in Figure 16, apply to one, two or three rectifier equipments as described herein.

The Telephone Receiver

Why the Permanent Magnet?



HE telephone receiver is probably the electrical device that is most frequently handled by the general public. Its essential parts are the iron diaphragm, the copper wire coil and the permanent magnet core.

The diaphragm is obviously the part which vibrating under the influence of the magnetic field, produces sound waves in the air; the coil is naturally the connecting link between the electric and magnetic circuits whereby vibrations in the current will produce vibra-

tions in the magnetic field; the core is, of course, a part of the magnetic circuit, but why is it a strong permanent magnet?

Firstly, suppose that the core is of soft iron and will not retain any magnetism, and that the current in the coil follows a pure sine wave as Figure I; then, quite independent of the direction of the current, the diaphragm will be pulled in whenever the current reaches a maximum value, positive or negative. During one cycle, the diaphragm will be drawn in twice, and released twice; that is, it will make two complete

sound waves for one cycle of current (Figure II). Consequently the sound waves will have twice the frequency of the current and will produce a higher note than intended—namely one octave above.

The pull of a magnet on a soft iron diaphragm at fixed distance varies as the square of the strength of the magnet. With a soft iron core, the strength of the magnet varies approximately as the currents in the coil, hence the magnetic pull varies almost as the square of the current. Now, as a sound wave of the human voice contains a lot of higher harmonies (sounds of high frequency) it follows that a current controlled by telephone transmitter will also contain these higher harmonies. Since the pull of the soft iron core varies almost as the square of the current (distance fixed) it follows that the effect of the harmonic is very much magnified, and as a result the sound wave is usually distorted beyond recognition.

So much for the soft iron core; let us see the improvements when the core is a permanent magnet, and the coil so wound that the influence of the current alone is small. Let b be the magnetic pole strength caused by the current in the coil— b varies as the current (approx.). Let B be the strength of the permanent magnet core. The total strength with current flowing equals $(B+b)$. Let P be the pull on the diaphragm, or the relative motion of the diaphragm with relation to the face of the iron core.

P varies as (total flux²). that is, as $(B+b^2)$ which equals $(B^2+2 B b+b^2)$.

As B has a fixed value, B^2 also has a constant value and does not produce any sound waves.

It has been stated that if the pull varies as the square of the current, we get large distortions. It naturally follows that where b^2 occurs in the formula, there is bound to be some distortion also. If now, we make the value of "B" (the permanent magnet) large, and the value of "b" (the influence of the current) small, the term " b^2 " becomes of little consequence.

P varies as $(B^2+2 B b+b^2)$

If " B^2 " is constant and b^2 is small, we practically have P varying as $2 B b$.

i.e. P varies as b which is the result we desire.

As all higher frequencies will be produced in the right proportions and there will not be any double frequencies, but we also find that the amplitude of variation depends on and varies as the strength of B . Hence a strong permanent magnet and a comparatively weak coil will produce a very close approximation to a true sound wave—Figure III.

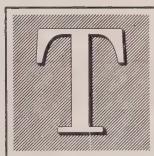
In long telephone lines, some means must be used to prevent the harmonies being increased due to the capacity of the line, or reduced due to the reactance of the line and instruments. The above discussion, however, is based on the current actually being passed through the coil of the telephone receiver.

Review of the Technical Press

Economical Increase Made in Distributing Capacity

By S. BINGHAM HOOD

Superintendent of Distribution, Northern States Power Company, Minneapolis



HERE have just been completed in Minneapolis, Minn., extensive changes to a large section of the distribution system which serves the residential section in the south end of the city. The steady growth of this district had resulted in overloading the old system of mains and feeders to a point where good service was impossible. For some years past it had been found necessary to reinforce feeders, erect larger or more numerous transformers and increase the size of secondary bus lines. These changes were made as increased loads demanded, and, being purely local in their corrective character, did not result in a general betterment of the system as a whole.

Realizing that such methods of correcting local troubles were leading nowhere, it was decided about two years ago to entirely revamp this section of the system. The old system consisted of a network of single-phase, 2300-volt primary

feeders and mains serving lighting and small single-phase motor loads. It included also several three-phase, 2300-volt feeders supplying the larger power loads, principally along a narrow strip following the railroad which bisects this section of the city. These feeders were supplied from a local step-down station fed from the 13,200-volt main feeder network.

The power feeders were unregulated, but each lighting feeder was equipped with an automatic induction regulator. Excessive drop from increased loads not only resulted in exceeding the safe carrying of the feeders themselves but made the voltage variation too great for compensation by the regulators. The natural result of this was that these feeders quite generally operated unregulated during the peak hours because every regulator was "up against" its limit stops. To make matters worse, the variation in drop between different sections of the same feeder was excessive, and, finally, the drop on secondary bus

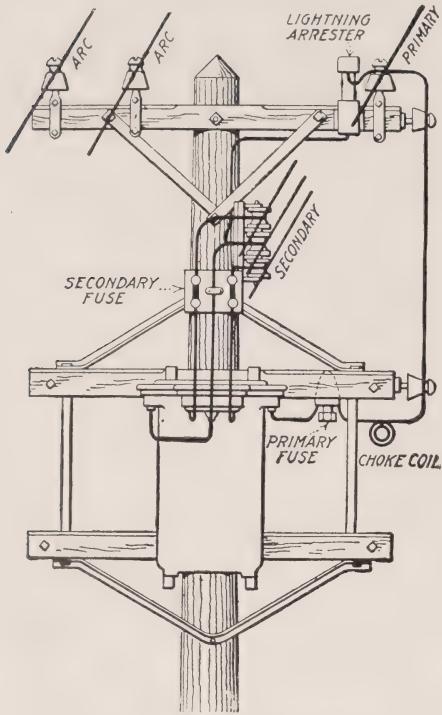


Fig. 6—Transformer Mounting

lines made service to the customers near their extreme ends anything but first-class.

The selection of the ultimate system was made a matter of most careful and extensive study, resulting in the adoption of the 2300/4000-volt star-connected primary three-phase system, using a common neutral. The secondary bus lines were interconnected throughout each phase section in a manner very similar to standard direct-current network practice. This "common-neutral" system is not by any means so well known or its advantages so well understood as they should be. It has been successfully employed for a number of years in several large cities, and

in every case has given most satisfactory results both as to economy and reliability.

Typical Example of 2300/4000-Volt Feeder Layout

In order to show just what this system is and to demonstrate its extreme simplicity, Figure 1 is given to illustrate a typical single-phase branch from a 2300/4000-volt feeder. Here are two short secondary bus lines, each supplied from its own transformer. The primary neutral is usually only grounded at point *A* in or near the substation. Each secondary neutral must also be grounded to comply with existing regulations. This method of operation has frequently resulted in serious trouble due to excessive currents during single-phase short circuits flowing over the primary neutral. Where this condition occurs the drop in pressure in this wire raises the potential to earth. In many cases this increase is sufficient to cause not only excessive voltage on the other two phases of the same three-phase feeder but also breakdowns in insulation.

In order to overcome such undesirable conditions it is quite generally the practice to place additional grounds at other points on this primary neutral, as indicated at *B*. This permits the earth to carry current in parallel with the regular metallic return. Under normal conditions the division of current over the two paths is such that no detrimental effects result. In the case of short circuits, however, the earth will carry considerable

current and the increase in potential due to distortion of the neutral is averted. Under some conditions this method of operation has been found to affect seriously local communication circuits where close parallelism occurs. With the "common-neutral" system such interference has been found to be of very rare occurrence and to be practically negligible.

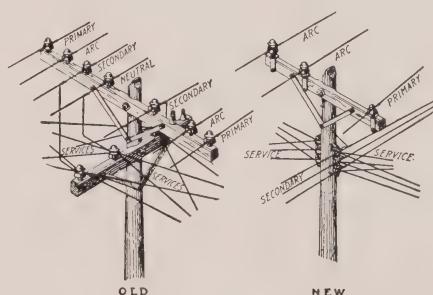
Referring again to Figure 1, it is clear that two wires of the system, the primary neutral and the secondary neutral, are paralleling each other. Both of these are grounded and are presumably held at the same potential, and with a well-designed system each carries very small currents normally. It therefore follows that if these can be safely combined into one wire, considerable economy will be effected. The secondary neutral, if it complies with established requirements, must be "permanently and effectively" grounded. This means that the secondary ground must protect against high-tension crosses under the most extreme abnormal operation conditions. If it will do this, it most evidently will also protect against any normal operating condition; therefore these two conductors can be safely combined if the neutral grounds are what they should be. In order to obtain an effective ground, "water-pipe" grounds must be used or a considerable number of driven-pipe or rod grounds connected in parallel.

Getting Away from Transformers with Taps for Odd Ratios

Referring to Figure 2, it will be noted that the secondary neutrals

have been interconnected at A' , placing all secondary grounds in parallel. This secondary neutral is extended back to the substation and connected to the neutral of the primary bank, which is grounded at the station also. In connecting the line transformers the primary lead to the phase wire is protected by a fuse, choke coil and compression-chamber lightning arrester. The other primary lead is carried around the case and connected solid to the secondary neutral lead. This is, briefly, what is termed the "common-neutral" system. With it only one-half the transformer auxiliary equipment is required, compared with a delta system or even a star system with the neutral grounded at the substation only.

A further advantage as regards transformers is the ability to use a standard twenty-to-one ratio transformer for ratios of nineteen to one, twenty to one and twenty-one to one without recourse to taps. These odd ratios are obtained by tapping the grounded primary lead of the transformer to either one or the other of the outer secondary leads, thereby converting a standard transformer into an auto-transformer.



Figs. 4 and 5—Old and New Service Connections on Pole

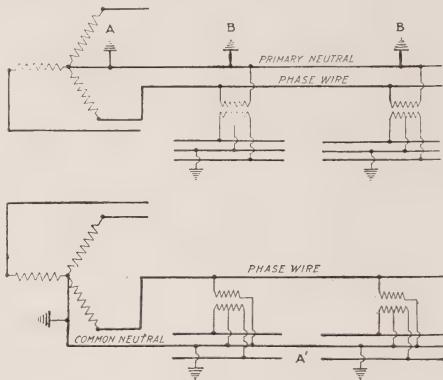
This scheme is often of value in serving a scattered territory from a single long feeder.

Not a Three-Phase Problem

In order to get a proper conception of this system it should not be considered as a three-phase problem, but as a straight single-phase proposition using a single potential-phase wire and a grounded return of negligible resistance. In starting this work of changing over the system, conditions were generally as illustrated in Figures 3 and 4, where the former represents the primary arrangement and the latter the short sections of secondary bus served. The first step taken was to interconnect all the secondary neutrals in order to form a neutral gridiron throughout the entire district served. The gaps between sections varied from several spans to that represented by the gap across insulating breaker knobs inserted between adjacent bus sections. These small secondary sections were mostly composed of three No. 6 B. & S. wires attached to cross-arms on which both series arc and primary wires were carried. Service taps were taken off from buck arms. The transformers varied in size from 5 kva. to 25 kva. and were mounted at the tops of the poles, being hung from the regular line arm.

In revamping this system of secondary mains with a view to later interconnection, a standard size of transformer (20 kva.) was selected. These units were generally installed on the cross-town streets at intervals of three blocks, every

second street being used for a cross-town main bus lead. On these cross streets a distributing bus was run, using No. 2 B. & S. for outers and No. 4 B. & S. for the neutral. Branch mains were then carried down intersecting alleys to complete the secondary grid. Where the load permitted existing mains were allowed to remain up, otherwise the outers were replaced with No. 4 B. & S., the neutral being left No. 6. In re-running these mains secondary racks were used in all cases. They were located 2 feet (0.6 m.)



Figs. 1 and 2—Regular and Common Neutral Systems

below the lowest high-tension line arm. Services taken off from the same side as the line rack were attached directly to this rack. Those on the opposite side were supported by a service rack of the same type as the other. Figure 5 gives some idea of the improved appearance of the rearrangement.

The various neutrals were run through solid between sections, the outers being sectionalized by inserting a standard porcelain breaker knob. When the final change-over

was completed these outer breaks were bridged by a jumper type of fuse block using a multiple copper-link fuse designed especially for this system. Each section of the secondary was so laid out that with these breaks open the load would be correctly apportioned to the transformer serving the section.

Standard Transformer Mounting Reduces Pole Stresses

In rearranging the transformers they were mounted on a new type of "standard" framing located so that the transformer would be 4 feet (1.2 m.) below the lowest line arm, the secondary line rack being placed midway in this pole space. Figure 6 shows this framing and indicates its advantages as regards accessibility and decreased pole stresses in comparison with the old pole-top mounting. Each transformer was fused temporarily on both sides of the primary, one leg being removed upon completion of the change-over, as is explained later. The secondary fuse, shown just above the transformer, is a special outdoor type of block using the copper-link multiple fuse on outer wires. The neutral goes through solid and is held rigid by a clip.

The rearranged secondary would appear as shown in Figure 7. This arrangement was employed over the entire district, in so far as practicable. In interconnecting, the fuses were of course left off these breaks which formed the division between primary sections served by different feeders and from different phases of the three-phase station bus.

The old primary scheme as shown in Figure 3 was that of running out a pair of No. 4/0 feeder wires from the substation to a load center. From this center branch mains were taken off through disconnecting blocks or oil switches to the several sections of the district served. In rearranging the district the territory was so divided that, roughly speaking, there would be three new sections for two old ones. Each new section required one No. 4/0 wire (ground return). This plan required running one additional wire feeder. Ultimately the nearest parallel feeder was removed. This meant using three out of four No. 4/0 wires between the station and the load, or a net saving on feeders of 25 per cent. In addition to this saving the feeder capacity was automatically increased on account of increased voltage by 50 per cent., and, assuming negligible return drop, the losses were reduced by 66 per cent. under present loading and by 50 per cent. when the ultimate increase of 50 per cent. is made in loading.

To complete the return circuit, heavy neutrals were taken out of the substation and carried in four directions for several thousand feet, tapping the secondary gridironed neutral network at each intersection. With this arrangement the return copper cross-section was very large, and no dependence was placed on the carrying capacity of the earth returns. It should be mentioned here that water-pipe grounds were liberally distributed over this entire neutral network, in addition to a

large number of older driven-pipe ground connections.

From the end of the No. 4/0 feeder wire of each single-phase section smaller single-wire primary mains were run. These were connected in a series of closed rings. This closed ring feature is essential to a successful operation of an interconnected secondary network, otherwise a break in primary will permit of a step-up-and-down transformation around the break. Such a condition, if permitted, forms the trap which has resulted in failure of so many interconnection schemes. The new primary arrangement is typically illustrated in Figure 7. Comparing this with the old arrangement of Figure 3 will show at once the gain in simplicity and uniformity in voltage distribution which must result.

Distinguishing Marks for Different Classes of Lines

In running these new primary lines, the old work, in so far as it was utilized, was overhauled, slack was pulled up, and the insulators were changed from glass to porcelain. A small 6600-volt porcelain insulator now is used to distinguish 2300/4000-volt primary wires from arc circuits. Secondaries being on racks, possess a distinguishing mark for the low-voltage group. The old second primary was allowed to remain until the time of change-over. It was reconnected where necessary to maintain the old circuit limits. Shortly before the change-over was made the old delta system was grounded and connected to the neutral network, this ground con-

nection being attached to the *B* or middle busbar in the station. Following this, those single-phase circuits which were supplied from the *A-B* and *B-C* busbars were converted to common neutral return. In this conversion the old second primary was taken down, and the fuses, choke coils and compression chamber arresters were removed from the grounded side of the transformers. The driven-pipe grounds formerly used only for the arresters were at this time tapped also to the common neutral. As the change-over was made the various secondary sections were tested out for polarity and were interconnected through the jumper blocks and fuses between sections.

On the final change-over the station transformers were changed from delta to star. At the same time the distribution network still supplied from the *A-C* pair of busbars was cut loose, one end of these sections being then tapped to the new feed supplied from the *B* bus, the other being grounded to the common return. Later these middle sections were cut over at each transformer and the surplus wire was removed exactly as had previously been done with the *A* and *C* sections.

Statement of Results and Savings Effected

It will be clear from the foregoing that the saving effected on the primary mains as well as the line transformer auxiliary equipment was just 50 per cent. In addition, there was a saving due to simplification of the distribution layout, as can readily

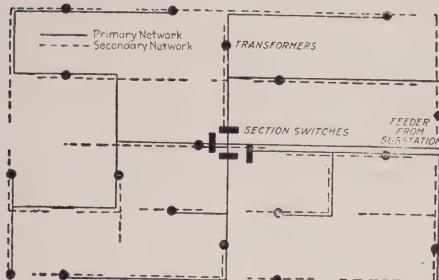


Fig. 3—Original Primary and Secondary Networks

be seen from comparison of Figures 3 and 7.

In converting the three-phase power circuits from delta to star considerable saving was effected by feeding small outlying power loads from overlaps from adjacent lighting feeders which were fed from different bus phases. This very considerably reduced the number of long but small three-phase primary branches in the system.

Where the power load was fairly well concentrated it was found economical to do considerable grouping. Most of the smaller power banks were operated open-delta, requiring either open-star operation or the installation of a third unit. By grouping these units advantage was taken of a wide diversity factor. In one case eighteen transformers, aggregating over 200 kva. in rating, were replaced by a single bank of three 30-kva. units. On the final change-over all that was necessary was to cut these remaining banks from delta to star on the primary side. In several cases customers were using the 2300-volt energy directly in their motors. For these auto transformers were installed, converting from 4000 volts to 2300 volts.

In this change-over the saving in transformers has been a very considerable economy. The total kilovolt-ampere capacity installed not only is less, but those units released have been of the smaller sizes, having a greater value per kilovolt-ampere. These small sizes released will serve to fill demands for some time to come in those suburban sections where small units are needed.

Supplying Fluctuating Loads

A further economical feature of the interconnected secondary network worthy of note is its ability to supply fluctuating loads. With the old systems of isolated secondary sections it was generally necessary to install individual transformers for rectifiers, X-ray outfits, single-phase motors, motion-picture machines and similar apparatus. All this equipment is now supplied from the regular secondary bus without noticeable interference with good lighting regulation.

The operation of this system is more than fulfilling all expectations. It has already successfully weathered several unusually severe lightning storms, these same storms having caused no end of trouble on the older system immediately adjacent to the district now served by the "common-neutral" system.

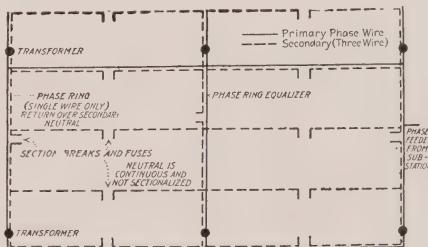


Fig. 7—New Primary-Phase Section and Secondary Networks

Who's Who in Hydro?

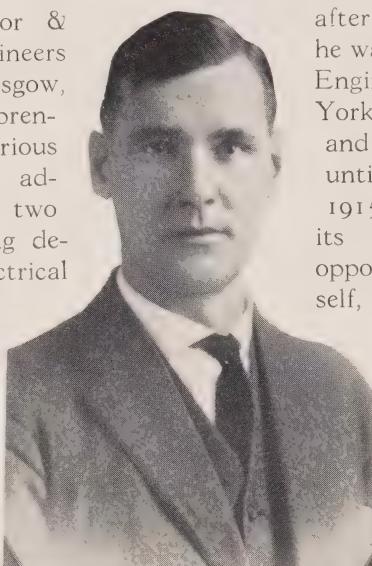


ALCOLM M. INGLIS, a native of Scotland, educated at the High School of Stirling and the Glasgow and West of Scotland Technical College. In 1901 entered the employ of Mavor & Coulson, Ltd., engineers and electricians, Glasgow, serving a regular apprenticeship in their various departments, and in addition completing two years in the designing department for electrical machinery.

He resigned in 1908 to become connected with Johnson & Philips, Ltd., of London, England, as Chief Tester and Erector. The following year became assistant designer to Professor Kahan, of the Brush Electrical Engineering Company,

Ltd., of Loughborough, England. In 1910 appointed Chief Electrical Engineer of W. Y. Craig & Sons at their Brynkinalt Collieries, North Wales, but severed this connection in 1911 to seek his fortune in the land of the Maple Leaf. Shortly after his arrival in Canada he was appointed Electrical Engineer to the Town of Yorkton, Saskatchewan, and served in this capacity until the latter end of 1915. The East having its attractions and the opportunity presented itself, early in 1916, Mr.

Inglis became connected with the Public Utilities Commission of the City of Port Arthur, Ontario, as Manager of the Light & Power, Street Railway & Telephone De-



MALCOLM M. INGLIS

partments, and continues in this capacity.

Courtesy Always

The business of this company is to sell a service, and a part of service—good service—is courtesy. Courtesy is a combination of good manners, cheerfulness, patience and self-control. Courtesy is not bowing and scraping; it is a standard of right thinking and right acting.

The times when an employee finds it hardest to be courteous are the very times he needs it most. Courtesy is not mere politeness; it is the cornerstone of individual character. Courtesy, as defined here, is an imperative rule of this company.—*A. G. & E. Bulletin.*

Hydro News Items

Severn System

COLLINGWOOD.—A new substation constructed for the purpose of supplying power to the steel plant operated by Messrs. William Kennedy & Son, has been completed and placed in operation. This station is served at 22,000 volts from the main distributing station in the Municipality. It is quite probable that an additional load will be secured at Collingwood in the near future, which will increase the demand in this Municipality to approximately 4000 H.P.

The Commission is investigating at the present time the various problems in connection with supplying this amount of power, in the nature of rate investigation and possibilities of developing and transmitting this additional load.

MIDLAND.—A 300 K.W. synchronous condenser has been installed recently by the local commission, and is now utilized for power factor correction. Practically all of the power utilized by munition plants in this municipality will be taken up by new and additional industries located in the municipality, and it is not anticipated that the loss of load formerly used by munition plants will in any way affect the demand for power in Midland.

STAYNER.—Additional equipment has been recently installed at the Georgian Bay Milling Company's plant, and an extension made to the distribution system by the Municipality to take care of the increased load.

GENERAL.—The extension of the Severn System in the southern part of the Simcoe County, the construction of which was begun in the latter part of 1917, has now been completed. This extension involved the construction of six substations, two being of brick construction and four being of an outdoor type. The capacities of these substations range from 25 K.W. to 300 K.W., and the transmission line consists of approximately 23½ miles of 1/8 aluminum, single circuit, 3-phase, 22,000 volt line, and 24½ miles of single circuit, 5/16 in. steel conductor line.

The new extension was constructed for the purpose of giving service to the following municipalities:—

| | |
|-----------------|-------------------------|
| Alliston . . . | Connected May 16, 1918. |
| Beeton . . . | " July 26, " |
| Tottenham . . . | " Sept. 9, " |
| Cookstown . . . | " Apr. 25, " |
| Thornton . . . | " Oct. 16, " |
| Bradford . . . | " Sept. 16, " |

Association Municipal Electrical Engineers

Winter Session, January 30 and 31, 1919



ARRANGEMENTS covering the Winter Convention of the Association of Municipal Electrical Engineers have been practically completed.

The meetings will be held in the Chemistry and Mining Building and the Engineering Building, University of Toronto.

The programme will consist of:—

A paper by W. B. Johnson, Manager, New Business Department, Montreal Light, Heat & Power Consolidated, entitled "The Advisability of Electric Companies Handling Appliances and Supplies and Maintaining Standard Prices as Established by the Manufacturers."

An address by W. L. Goodwin, Electric Company, New York, on the "Goodwin Plan."

A talk on Power Factor and demonstration by W. H. Price, Associate Professor of Electrical Engineering, University of Toronto, with Oscillograph.

A paper by A. S. L. Barnes, Assistant Engineer, Hydro-Electric Power Commission of Ontario, entitled "Bare Versus Weather-proof-covered Wires for Potentials above 750 volts."

On the evening of January 30th, there will be an Association Supper, when Mr. C. H. Hopper, Sales Manager, Canadian Westinghouse Co., will speak.

The election of officers for the coming year will be held during the convention.

The Goodwin Plan



WILLIAM L. GOODWIN, who will address the Convention of the Municipal Electrical Engineers' Association in Toronto, January 9th, is the author of the "Goodwin Plan."

The Goodwin Plan is the basis of a campaign of education conducted principally through trade papers, trade organizations and other channels to co-operate the various interests in the electrical industry, so that there may be established retail distribution of electrical materials at fair prices to the consumer, and a fair profit to all parties taking part in the transactions.

The electrical manufacturers, jobbers, central stations, contractors and dealers throughout the United States have been rapidly interested in the movement.

Mr. Goodwin, several years ago organized the electrical industry on the Pacific Coast, where his plan was put in operation. The results obtained were an enormously increased per capita sales, the introduction of adequate cost accounting, improved credits and harmonious relations between the various interests. The promoters of the Goodwin Plan hope to extend such conditions throughout the country.

Letters from Readers

Canadian Engineers,
Seaford Camp,
Seaford, Sussex, Eng.
(c/o Army Post Office, London)

27-11-'18.

Dear Hydro:

I now take the pleasure of writing you a few lines, as I am at last settled in our regular training camp. Since leaving Canada I have had a rather exciting experience. We left Canada on September 26th, setting sail at Montreal, and on October 11th we landed in England, after having a very miserable voyage, it being cold, wet and exceedingly rough. We had not left the Canadian shores very long when a number of us were taken down with influenza, I being one of the number. For the last ten days of our voyage I was a patient in the boat's hospital and after landing was taken to one of the hospitals in the City of Exeter, about one hundred miles inland.

I remained there for three weeks, then was sent to a Canadian Convalescent Hospital at a place called Workingham, about two hundred miles further on from Exeter. After remaining there for a time was sent on to the Engineers Camp at Seaford; at present I am attached to that part of the camp where men are kept who are unable to drill, but as I am feeling very well now, expect to be moved very soon to the regular reserve. You can see from the above that I have had quite a time, and have every reason to be thankful that I am alive.

During our voyage we lost 35 of our men with influenza and they were buried at sea; we took off after landing, over one hundred stretcher cases who were placed in the hospitals at that place and we learned later that 75 of those cases died, so you see that this influenza is worth keeping clear of, if it is at all possible. I have heard that it is now raging in Canada but I hope you all have escaped the disease.

Well, at last the day that has long been looked for has arrived and I can assure you it is appreciated by all. At the time the armistice was signed, I was at Wokingham Hospital—at eleven o'clock that morning we received the news by way of bells ringing, whistles blowing from the City of Reading three miles distant. It was not necessary to get any further word, we all knew quite well what it meant and it was not long until all the walking patients were out and perhaps we did not have a real demonstration; everybody went wild, the officers and whatever nurses could get away went to London, a distance of about thirty miles, for the rest of the day and evening. They told us the city was simply crowded with people and such a demonstration was never known. It was almost impossible to pass through the streets. We all feel now that sooner or later we shall be back again in Canada and return to our different homes, once more to live in peace.

We have had remarkable weather since I landed here. It has been quite mild and exceedingly fine. Sunday I saw roses and other flowers in full bloom. I have seen very little frost thus far. To-day it has rained all day, perhaps from now on we will have plenty of rain as this country is noted for wet weather.

I expect to go to London soon for six days. After landing we are all entitled to shore leave but on account of the influenza rage, all passes were cancelled, but as they have decided it is not necessary to hold the boys longer, we hope for our turn soon.

Having spent most of my time in the hospitals, I have very little of interest to tell you. I notice a vast difference in this country as far as electricity is concerned. Electricity does not appear to be used extensively; every place I have been in, gas is generally used for lighting both for residential and street-lighting. Up to the time the Armistice was signed, you would see one street light here, with all the top part of the glass case painted black and about four or five hundred feet away, you would see another. Now all the glasses are cleaned off and about every other lamp lighted. The entire street lighting is not carried out, as fuel is very short over here and at the best the streets are very dark. If those people saw some of the Canadian cities lighted they would surely get a surprise. At the

camp here they generate their own electricity and all huts are lighted. They run five machines with gas engines. This is the only plant I have seen since coming over here. After my visit to London I'll be able to tell you more about the place.

Well the thing that concerns us mostly just now is when we are going to get home. The Government appears to be doing very good work, quite a number of married and low category men have already left the camp for home, but when one considers the number of soldiers, including United States men over here, those who came last feel they may be obliged to wait for some time. The English Government, I believe, is going to discharge as many men as possible who were filling positions of national importance, as soon as they start demobilizing. If the Canadian Government does that, some of us may get back sooner than we might if nothing along that line were done. However, they cannot get me back into civil life too soon, for I am anxious to get there as speedily as possible.

By the time you get this letter it will be very close to Christmas and I take this opportunity of wishing you all a Merry Christmas and a Happy New Year.

Yours very truly,

George F. Harrington
No. 3060195.



50% MORE LIFE!

For Your TUNGSTEN and NITRO Lamps

Makers of ordinary Tungsten and Nitro Lamps have always claimed 1000 hours as the useful life of a lamp, but official tests of such grades prove that the actual life is, in many cases, only 700 hours.

HYDRO QUALITY LAMPS

From actual experience, covering a period of over five years, have shown an average life of 1500 HOURS, consequently, Hydro Lamps are now

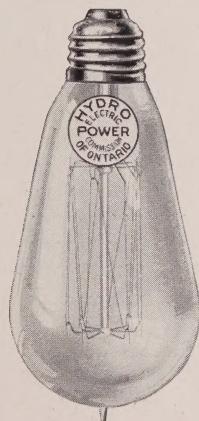
Guaranteed for 1500 Hours

or approximately the number of hours a lamp will burn in twelve months.

You save money and conserve power by buying the 1500 Hour Hydro Quality Lamps.

The ordinary lamp may cost less to start with, but the HYDRO saves money in the end. The light remains always clear and brilliant; they do not blacken and the current consumption is low.

THE HYDRO LABEL Represents Economy and Efficiency



WHEN YOU NEED LAMPS

ASK FOR **HYDRO QUALITY LAMPS**
AT YOUR HYDRO SHOP

Index to Volume IV.

| A. | Page |
|--|-----------------------|
| A. M. E. E. | 2, 3, 4, 10, 13 to 24 |
| A. M. E. E. Delegates.... | 39, 40, 41 |
| " President's Address.... | 41, 42 |
| " Minutes of..... | 24, 127, 128 |
| " Secretary's Report.... | 42, 43 |
| " Treasurer's Report.... | 43, 44 |
| Annual Report, Tenth..... | 73, 74, 75 |
| A Ray of Hope..... | 65 |
| Are you Saving?..... | 132 |
| B. | |
| Brighten Up Your Window..... | 83 |
| Buying Lamps Under Specifications..... | 129, 130 |
| C. | |
| Catchy Cards Help Sales..... | 79 |
| Caughell, E. H..... | 164 |
| Commercial..... | 49, 50, 77-79, 99-103 |
| | 129, 130, 153-155 |
| Complete House Wiring..... | 54 |
| C. O. S. Man Passes Away..... | 147 |
| D. | |
| De Bats, C. J..... | 108 |
| Demand-Meter Situation..... | 159-163 |
| E. | |
| Effect of Artificial Light on Plant Growth..... | 55, 56 |
| Eighteen Times More Light Than 1815 | 128 |
| Electrical Club of London..... | 75 |
| Electrical Shop Should Be Simple and Attractive..... | 100-103 |
| Electrical Welding..... | 111-118 |
| Electricity—The Nation's Conservator | 79 |
| Elimination of Unnecessary Shock.. | 64, 65 |
| Electro-Thermal Lightning Arresters | 95, 96 |
| Enormous Cat Darkens City..... | 131 |
| Essex County System..... | 84-87 |
| Evolution of Electrical Inspection in Ontario..... | 4-9, 11, 13 |
| Exit Espenschied..... | 48, 49 |
| F. | |
| Fall Lamp Advertising..... | 2 |
| Fisk, H. O..... | 131 |
| Folger, C. C..... | 98, 108 |
| G. | |
| Ground Connection for Distribution System..... | 45, 46, 47 |
| H. | |
| Heating and Cooking By Electricity | 93, 94, 95 |
| H. E. P. C. Victory Loan Record | 172, 173, 174 |
| Household Labor Savers..... | 44 |
| I. | |
| Inadequately Wired Houses. | |
| "The Bugbear of Electric Merchandising"..... | 57, 58 |
| Interesting Range Policy of a Company in South West..... | 97 |
| K. | |
| Keep Electric Lamps Clean and Save Light..... | 123 |
| L. | |
| Letters from Readers..... | 178, 179, 180 |
| London Opens New Store and Office Building..... | 66-73 |
| M. | |
| McClellan, K. R., Dead..... | 174 |
| McIntyre, V.S., Kitchener..... | 76 |
| Midland..... | 108 |
| N. | |
| New Humidifier Testing Evasion..... | 122 |
| News From The Front..... | 76, 148-152 |
| News Items..... | 175-180 |
| O. | |
| Off The President's Bat..... | 58-63 |
| Oxide Film Lightning Arrester..... | 96, 97 |
| P. | |
| Peace and Better Business..... | 134 |
| Perry, O. M..... | 48 |
| Perth..... | 126 |
| S. | |
| Salesmanship, The Ten Commandments of..... | 63, 64 |
| Service Boxes in Guelph..... | 135, 136 |
| Selling the Prospect | |
| On What It Can Do For Him.. | 103-108 |
| Some Reminiscenses and Observations | 165-171 |
| Stapleton, E. J..... | 108 |
| Synchronous Motors | |
| Commercial Application of | 24-39 |
| T. | |
| Talk at Convention Dinner..... | 88, 89 |
| Ten Ways to Kill An Association..... | 136 |
| The Convention..... | 89-92 |
| This Matter of Selling Appliances.. | 123-126 |
| W. | |
| Wanted, Articles from Managers..... | 158 |
| Water Power in The Empire..... | 119-122 |
| Water Power Resource of The British Empire..... | 137-146 |
| Women and Electricity..... | 171 |
| Y. | |
| Yates, P. B..... | 147 |

Hydro Municipalities

NIAGARA SYSTEM

25 Cycles

| NAGARA SYSTEM | | | |
|---------------------|---------|----------------------------|------------------------------|
| Acton. | 1,570 | Pop. | Seaford..... 2,075 |
| Ailsa Craig. | 462 | | Simcoe..... 4,032 |
| Aylmer. | 2,119 | | Springfield..... 422 |
| Ayr. | 780 | | St Catharines..... 17,917 |
| Baden. | 710 | | St. George..... 600 |
| Beachville. | 503 | | St. Jacobs..... 400 |
| Blenheim. | 1,257 | | St. Mary's..... 3,960 |
| Bolton. | 727 | | St. Thomas..... 17,216 |
| Bothwell. | 695 | | Stamford Township..... 3,418 |
| Brampton. | 4,023 | | Stratford..... 17,371 |
| Brantford. | 26,601 | | Streetsville..... 2,816 |
| Brantford Township. | 7,739 | | Tavistock..... 500 |
| Breslau. | 500 | | Thamesford..... 974 |
| Brigden. | 400 | | Thamesville..... 504 |
| Burford. | 700 | | Thorndale..... 742 |
| Burgessville. | 300 | | Tilbury..... 250 |
| Caledonia. | 1,236 | | Tillisburg..... 1,605 |
| Chatham. | 13,943 | | Toronto..... 3,059 |
| Clinton. | 1,981 | | Toronto Township..... 5,008 |
| Comber. | 800 | | Vaughan Township..... 4,059 |
| Dashwood. | 350 | | Walkerville..... 5,349 |
| Delaware. | 350 | | Wallaceburg..... 4,107 |
| Dorchester. | 400 | | Waterdown..... 696 |
| Drayton. | 613 | | Waterford..... 1,027 |
| Dresden. | 1,403 | | Waterloo..... 5,091 |
| Drumbo. | 400 | | Waterloo Township..... 6,538 |
| Dublin. | 218 | | Watford..... 1,115 |
| Dundas. | 4,834 | | Welland..... 7,905 |
| Dunnaville. | 3,286 | | West Lorne..... 708 |
| Dutton. | 840 | | Wellesley..... 583 |
| Elmira. | 2,065 | | Weston..... 2,283 |
| Elora. | 1,005 | | Windзор..... 26,524 |
| Embroy. | 472 | | Woodbridge..... 615 |
| Erin. | 502 | | Woodstock..... 10,004 |
| Etobicoke Township. | 5,822 | | Wyoming..... 526 |
| Exeter. | 1,504 | | Zurich..... 450 |
| Fergus. | 1,679 | | |
| Forest. | 1,421 | | Total 1,011,978 |
| Galt. | 11,920 | | SEVERN SYSTEM |
| Georgetown. | 1,654 | | 60 Cycles |
| Goderich. | 4,553 | Alliston..... 1,237 | |
| Grantham Township. | 3,133 | Barrie..... 6,866 | |
| Grantont. | 300 | Beeton..... 588 | |
| Guelph. | 16,022 | Bradford..... 946 | |
| Hagersville. | 1,053 | Coldwater..... 617 | |
| Hamilton. | 104,491 | Collingwood..... 7,010 | |
| Harriston. | 1,563 | Cookstown..... 6,355 | |
| Hensall. | 717 | Creemore..... 599 | |
| Hespeler. | 2,887 | Elmvale..... 773 | |
| Highgate. | 427 | Midland..... 7,109 | |
| Ingersoll. | 5,300 | Orillia..... 7,448 | |
| Kitchener. | 19,380 | Penetang..... 3,672 | |
| Lambeth. | 350 | Port McNichol..... 500 | |
| Listowel. | 2,291 | Stayner..... 990 | |
| London. | 57,301 | Thornton..... 250 | |
| Lucan. | 643 | Tottenham..... 557 | |
| Lynden. | 662 | Victoria Harbor..... 1,542 | |
| Milton. | 1,947 | Wautaushene..... 600 | |
| Milverton. | 929 | | Total 41,941 |
| Mimico. | 2,004 | | WASDELL'S SYSTEM |
| Mitchell. | 1,656 | 60 Cycles | |
| Mount Brydges. | 500 | Beaverton..... 821 | |
| New Hamburg. | 1,398 | Brechin..... 215 | |
| New Toronto. | 1,423 | Cannington..... 746 | |
| Niagara Falls. | 11,715 | Sunderland..... 570 | |
| Norwich. | 1,093 | Woodville..... 357 | |
| Oil Springs. | 537 | | Total 2,709 |
| Otterville. | 500 | | NIPISSING SYSTEM |
| Palmerston. | 1,843 | 60 Cycles | |
| Paris. | 4,437 | Callander..... 650 | |
| Petrolia. | 3,047 | Nipissing..... 400 | |
| Plattsburgh. | 550 | North Bay..... 9,651 | |
| Point Edward. | 937 | Powassan..... 572 | |
| Port Credit. | 1,176 | | Total 11,273 |
| Port Dalhousie. | 1,318 | | MUSKOKA SYSTEM |
| Port Stanley. | 831 | 60 Cycles | |
| Preston. | 4,949 | Gravenhurst..... 1,600 | |
| Princeton. | 600 | Huntsville..... 2,135 | |
| Ridgeway. | 2,080 | | Total 3,735 |
| Rockwood. | 650 | | |
| Rodney. | 626 | | |
| Sandwich. | 3,077 | | |
| Sarnia. | 12,323 | | |

EUGENIA SYSTEM

60 Cycles

| | Pop. |
|-------------------------|---------------|
| Alton..... | 700 |
| Artemesia Township..... | 2,396 |
| Arthur..... | 1,003 |
| Chatsworth..... | 286 |
| Chesley..... | 1,860 |
| Dundalk..... | 750 |
| Durham..... | 1,520 |
| Elmwood..... | 500 |
| Flesherton..... | 428 |
| Grand Valley..... | 586 |
| Hanover..... | 3,310 |
| Holstein..... | 285 |
| Horning's Mills..... | 350 |
| Markdale..... | 904 |
| Mount Forest..... | 1,871 |
| Neustadt..... | 470 |
| Orangeville..... | 2,381 |
| Owen Sound..... | 11,819 |
| Shelburne..... | 1,018 |
| Tara..... | 620 |
| Total | |
| | 33,057 |

OTTAWA SYSTEM

OTTAWA ST
60 Cycle

| PORT | ARTHUR | SYSTEM |
|------------------------|-----------|--------|
| | 60 Cycles | |
| Port Arthur. | | 15,224 |
| CENTRAL ONTARIO SYSTEM | | |
| | 60 Cycles | |
| Belleville. | | 12,080 |
| Bowmanville. | | 3,545 |
| Brighton. | | 1,278 |
| Cobourg. | | 4,457 |
| Colborne. | | 811 |
| Deseronto. | | 2,061 |
| Kingston. | | 22,265 |
| Lindsay. | | 7,752 |
| Madoc. | | 1,114 |
| Millbrook. | | 746 |
| Napanee. | | 2,881 |
| Newburgh. | | 444 |
| Newcastle. | | 600 |
| Omemeet. | | 446 |
| Orono. | | 700 |
| Oshawa. | | 8,812 |
| Peterboro. | | 19,816 |
| Port Hope. | | 4,486 |
| Stirling. | | 823 |
| Trenton. | | 5,169 |
| Tweed. | | 1,350 |
| Whitby. | | 2,902 |

Total 101,

T. LAWRENCE
60 Cycles

| | 60 Cycles |
|-------------------|-----------|
| Brockville..... | 9,473 |
| Chesterville..... | 868 |
| Prescott..... | 2,630 |
| Williamsburg..... | 100 |
| Winchester..... | 1,042 |

Total

DE AUL SV

RIDEAU SYSTEM
60 Cycles

Total MISSING SYSTEM

MISSING SYS
60 Cycles

| | 60 Cycles |
|-----------|-----------|
| Callander | 650 |
| Nipissing | 400 |
| North Bay | 9,650 |
| Powassan | 572 |

204

TO
SHOW A SUSP

MUSKOKA SYSTEM
60 Cycles

Total 9,

COUNTY
60 Chel.

| | 60 Cycles |
|--------------|-----------|
| Amherstburg | 1,990 |
| Canard River | 50 |
| Cottam | 100 |
| Essex | 1,429 |
| Harrow | 373 |
| Kingsville | 1,632 |
| Leamington | 3,60 |

THE aim of the
Bulletin is to
provide municipalities
with a source of information
regarding the
activities of the Com-
mission; to provide a
medium through which
matters of common
interest may be
discussed, and to
promote a spirit of
co-operation between
Hydro Municipalities.